



# Pointshop 3D

## An Interactive System for Point-based Surface Editing

Matthias Zwicker

Mark Pauly

Oliver Knoll

Markus Gross



ETH Zürich

# Outline

- Introduction
- Pointshop3D system components
  - Point cloud parameterization
  - Dynamic sampling
  - Editing operators
- Demo
- Conclusions

# Point-Based 3D Content Creation

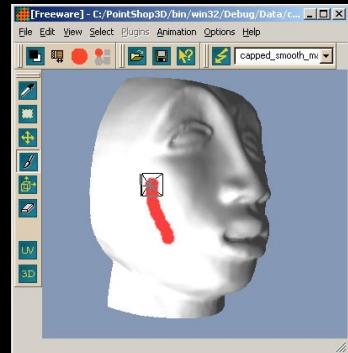
## Acquisition



- structured light
- laser scanning
- etc.

produces  
cloud of point  
samples

## Pointshop 3D



- texturing
- sculpting
- filtering

directly  
modifies point  
samples

## Display

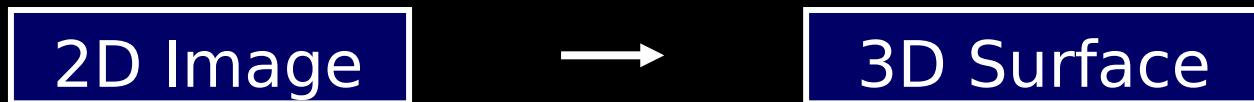


- surface  
splatting
- Qsplat
- etc.

uses points as  
rendering  
primitive

# Pointshop 3D

- Generalizes 2D photo editing concepts and functionality to 3D point-sampled surfaces



Pixel:

- color
- alpha
- ...



Surfel:

- pixel +
- position
- normal
- radius



⇒ Geometry editing: modify 3D positions and normals, e.g. sculpting and filtering

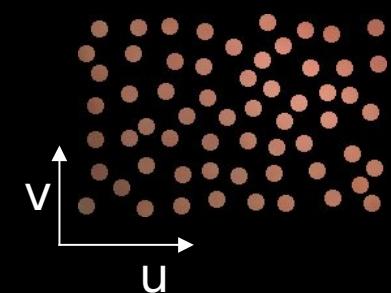
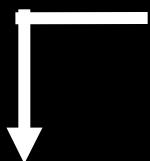
# Editing Operation



# Editing Operation

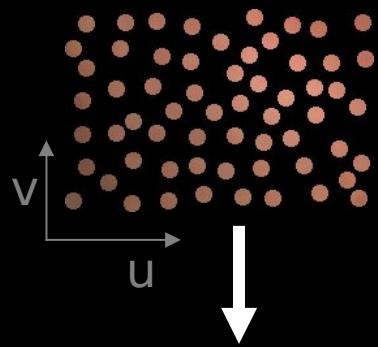
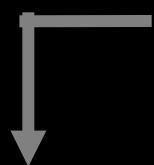
Parameterizati

on



# Editing Operation

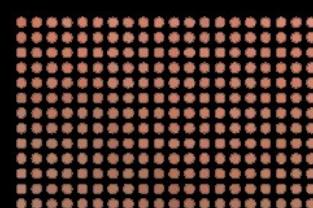
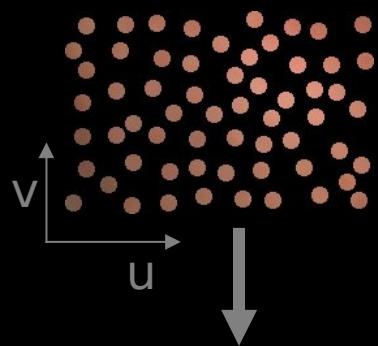
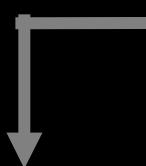
Parameterizati  
on



Reconstructi  
on

# Editing Operation

Parameterizati  
on

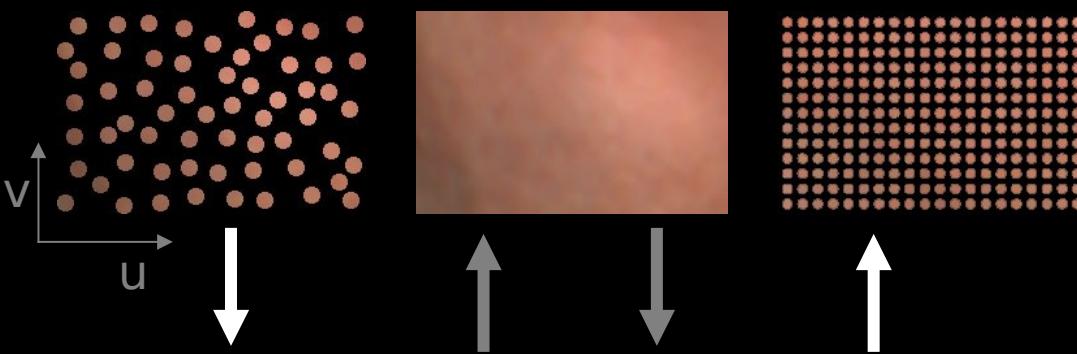
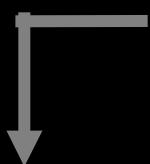


Reconstructi  
on

Samplin  
g

# Editing Operation

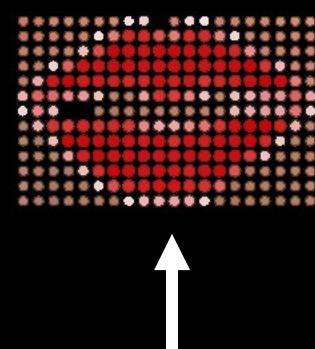
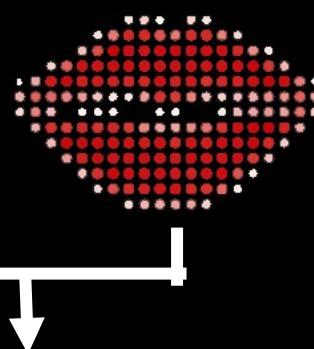
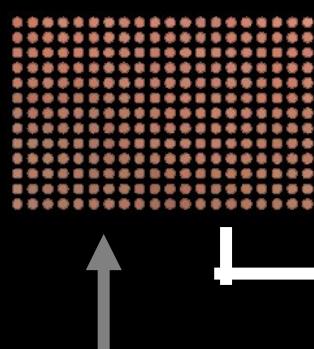
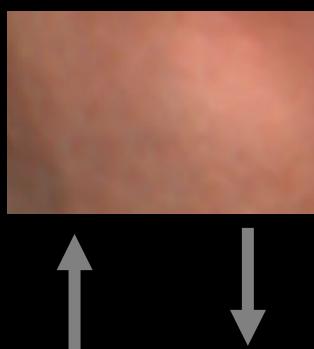
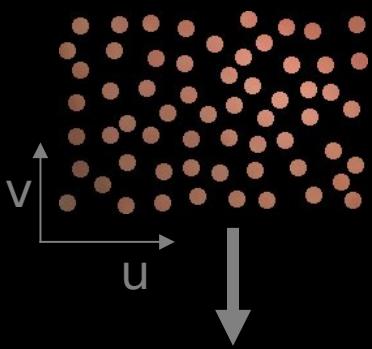
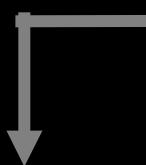
Parameterizati  
on



Resampling Operator

# Editing Operation

Parameterizati  
on

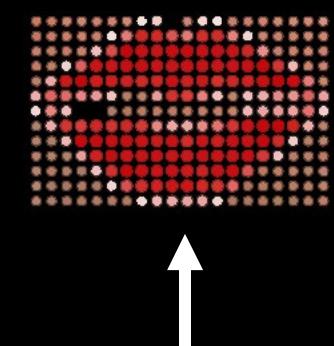
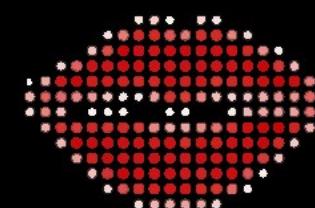
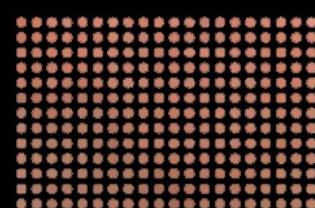
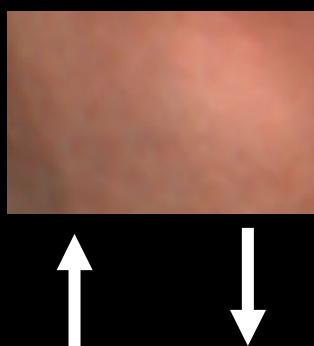
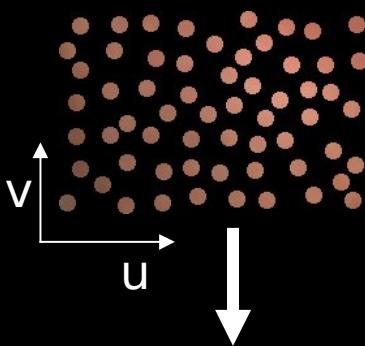
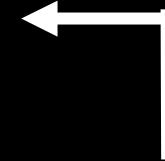
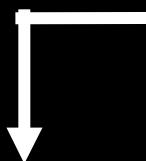


Resampling Operator

Editing Operator

# Editing Operation

Parameterizati  
on

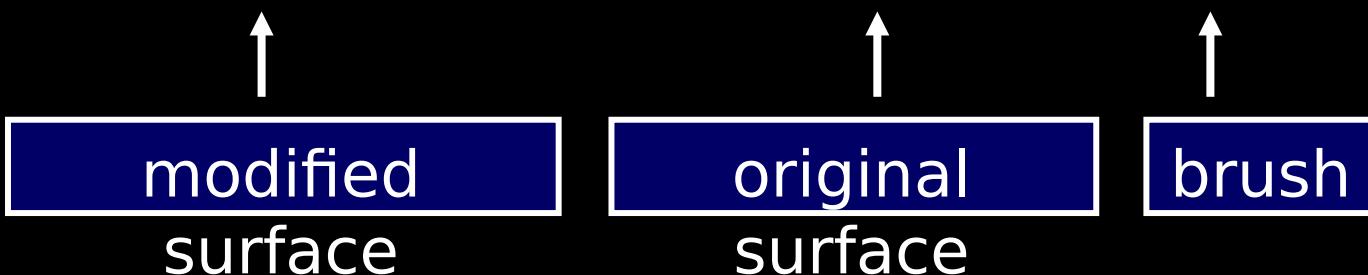


Resampling Operator

Editing Operator

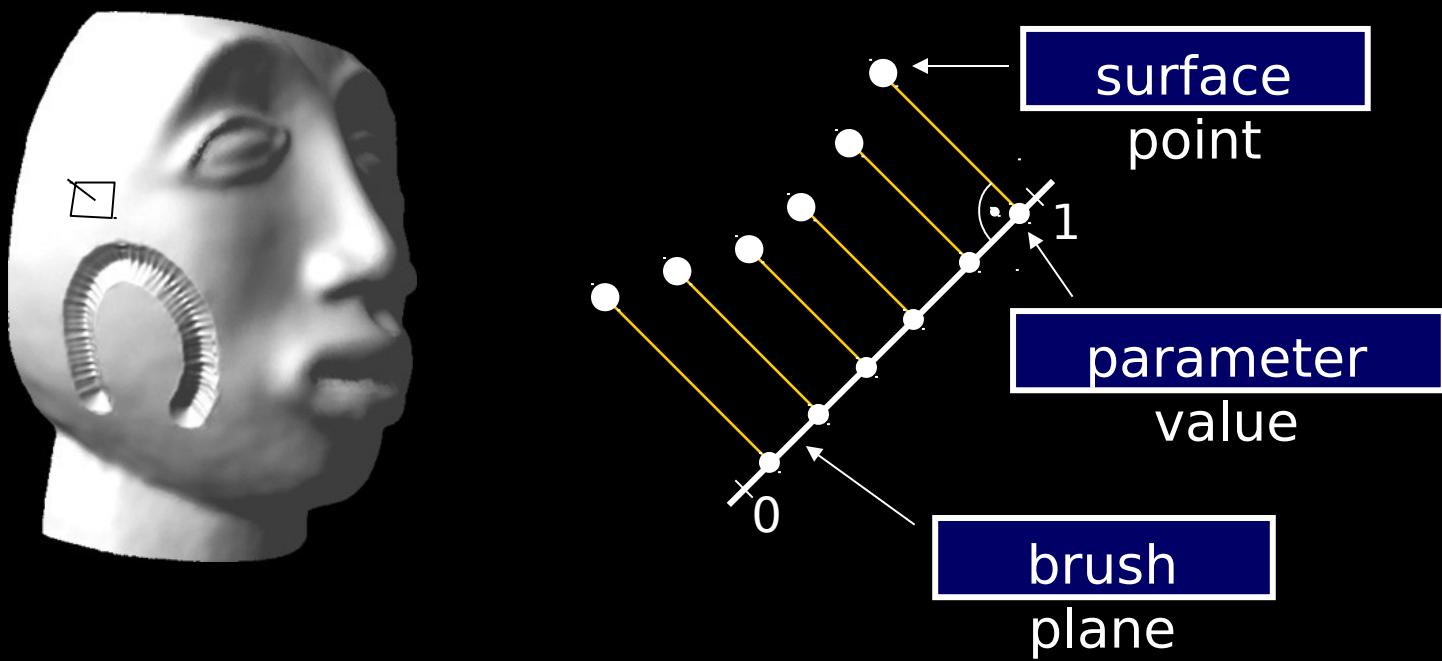
# Key Components

- Point cloud parameterization
- Dynamic resampling
- Editing operator



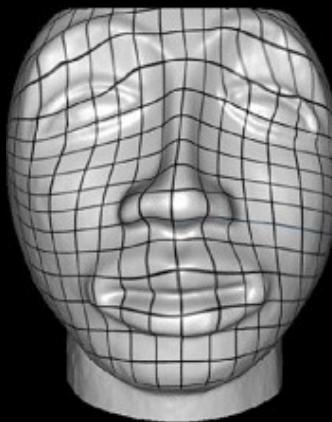
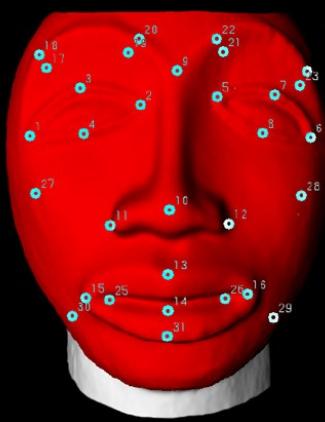
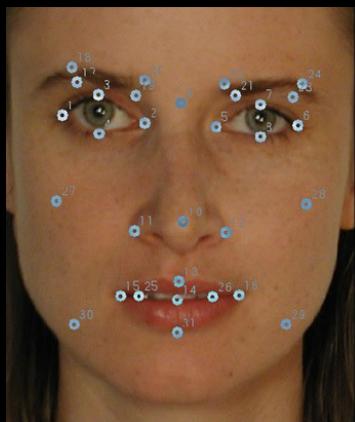
# Point Cloud Parameterization

- Brush interaction
  - Parameterize by orthogonal projection



# Point Cloud Parameterization

- Selection interaction
  - Constrained minimum distortion parameterization



Constraints

Minimum Distortion

# Point Cloud Parameterization

- Minimize objective function

brush points

surface  
points

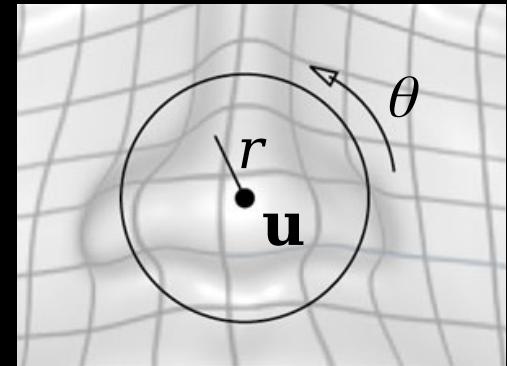


fitting  
constraints

distortion

# Point Cloud Parameterization

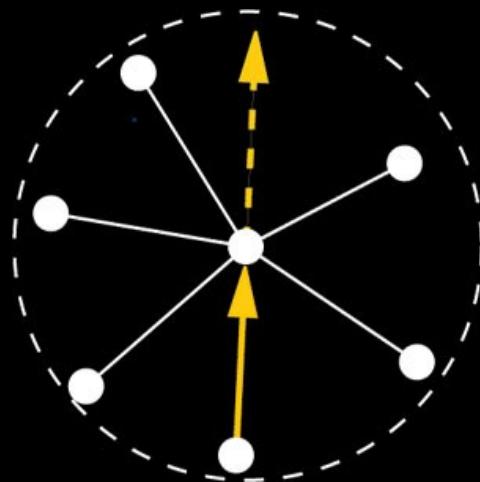
- Measuring distortion



- Integrates squared curvature using local polar re-parameterization

# Point Cloud Parameterization

- Discrete formulation:
  - Approximate second derivative with divided differences
  - Discretize integral using normal sections based on k-nearest neighbors

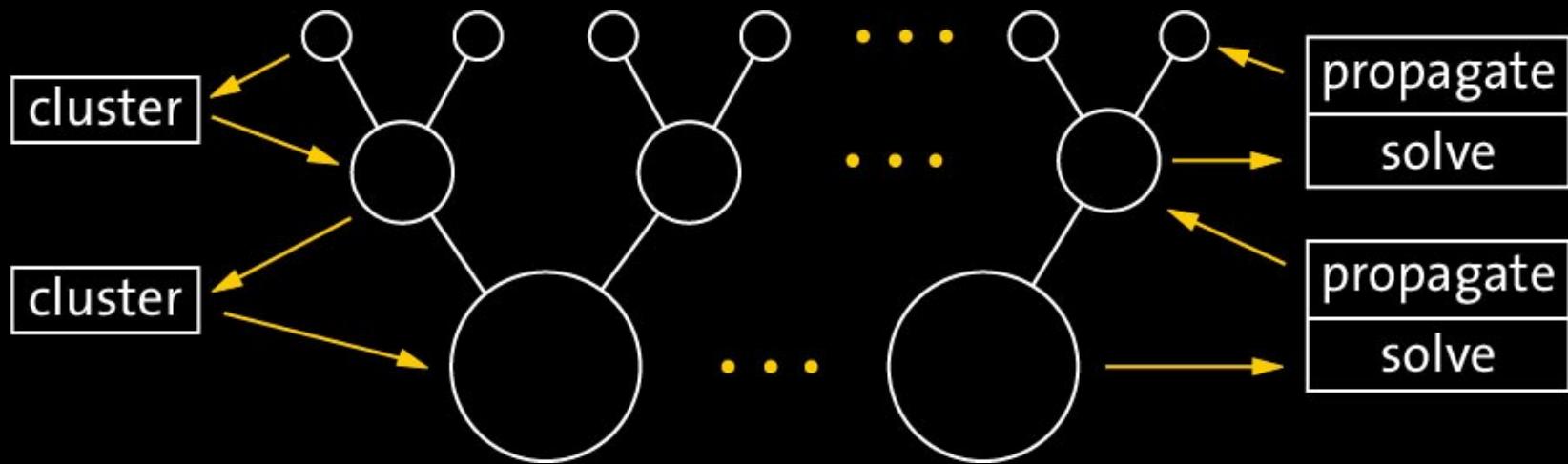


discrete  
curvature

k-  
neighborhood

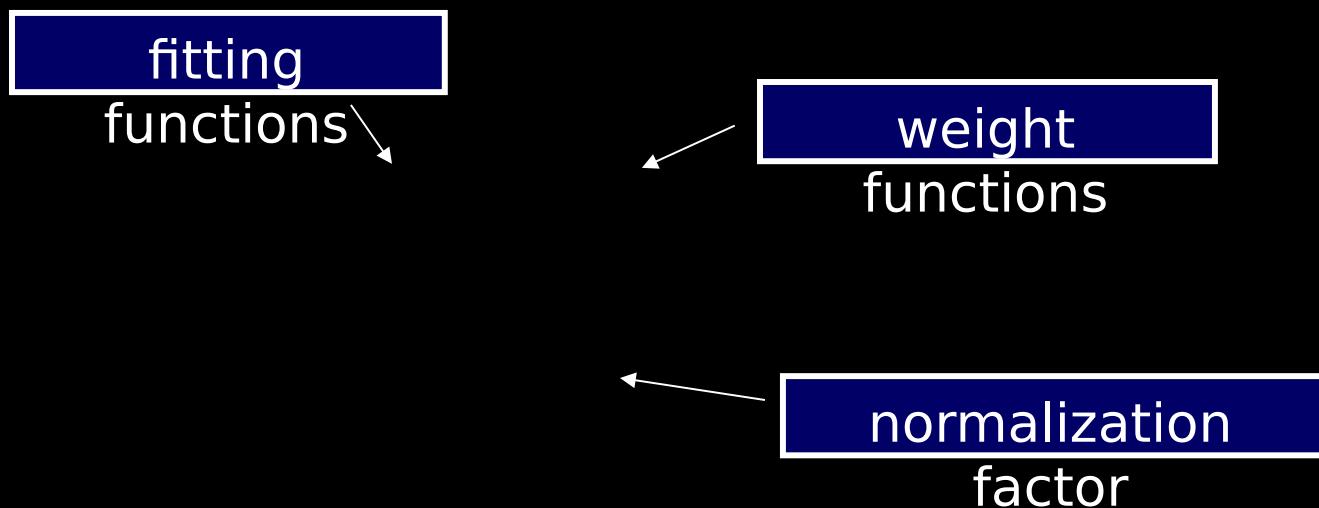
# Point Cloud Parameterization

- Discrete formulation:
  - Leads to a linear least squares system
  - Efficiently solved using multi-grid approach



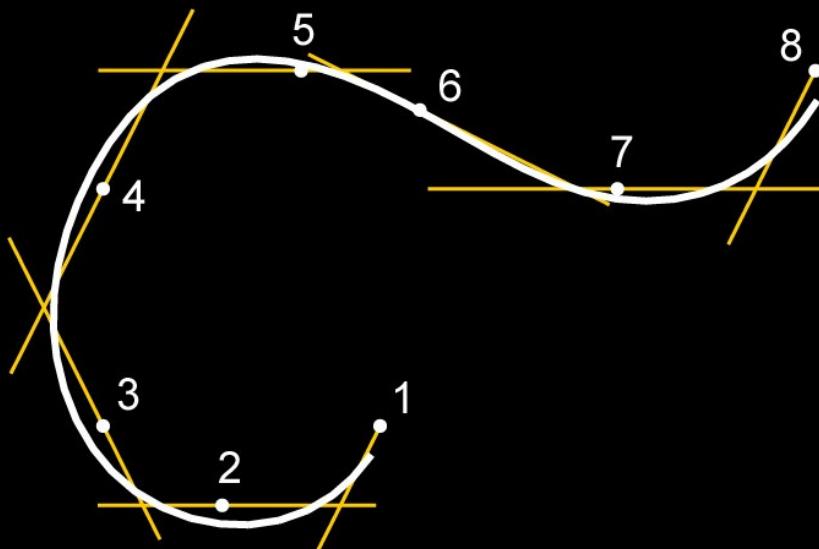
# Reconstruction

- Parameterized scattered data approximation

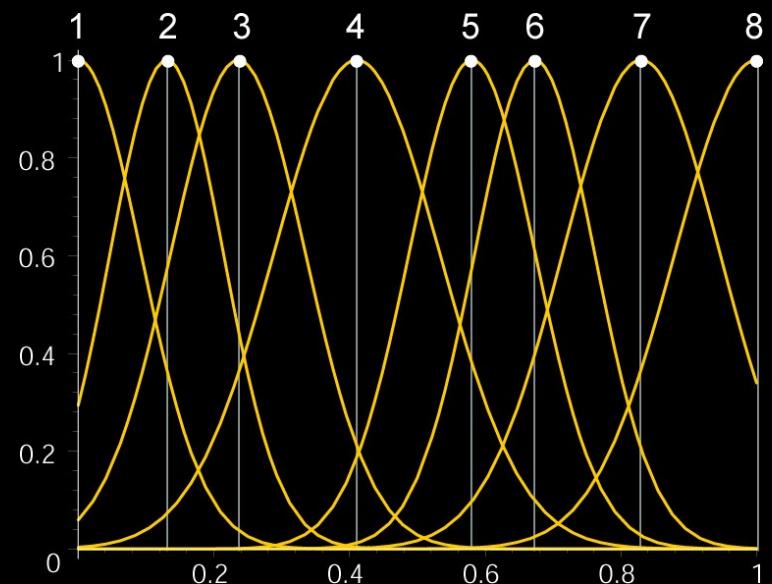


- Compute local fitting functions using local parameterization
- Map to global parameterization using global parameter coordinates of neighboring points

# Reconstruction



reconstruction with  
linear fitting  
functions



Gaussian weight  
functions in parameter  
space

# Sampling

- Three sampling strategies:
  - Sample at the original surface points
  - Sample at the brush points
  - Adaptive sampling, i.e. sample at surface or brush points depending on the local sampling density
- Antialiasing
  - Band-limit the weight functions (Gaussians) before sampling using Gaussian low-pass filter
    - ⇒ Surface splatting framework

# Editing Operators

- Painting
  - Texture, material properties, transparency



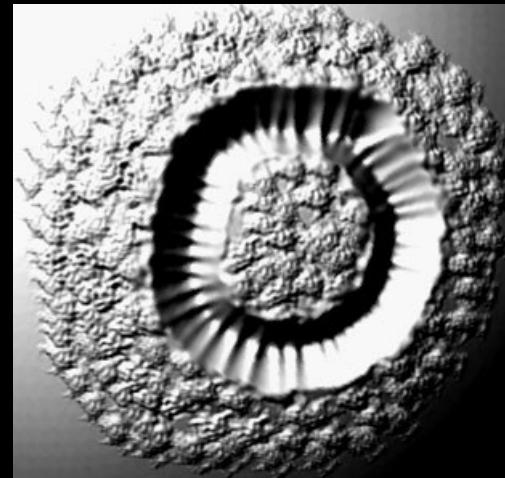
# Editing Operators

- 3D Sculpting



brus  
h

normal  
displacement

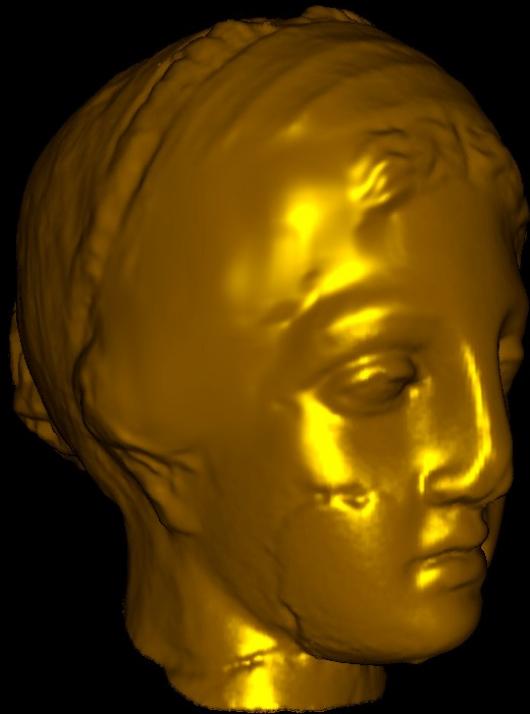


carving on a rough  
surface

brus  
h

# Editing Operators

- Filtering



geometry smoothing  
filter



artistic texture  
filter

# Demo

# Discussion

- Efficient point-based surface resampling
- Robust reconstruction based on k-nearest neighbors requires:
  - No outliers
  - Sufficiently high, roughly uniform sampling density
  - Little noise
- Geometry editing is restricted to displacements

# Ongoing & Future Work

- Model cleaning
  - User-guided  $\Rightarrow$  provide appropriate tools
  - Automatic pre-process
- More general modeling functionality
  - Free-form deformation
  - Physics-based modeling
- Texture synthesis and transfer

# Conclusion

- Pointshop3D provides sophisticated editing operations on point-sampled surfaces
  - ⇒ points are a versatile and powerful graphics primitive
- Software release in fall 2002 on  
[redacted]

[www.pointshop3d.com](http://www.pointshop3d.com)

# Acknowledgements

- Tim Weyrich
- Martin Roth
- CGL, ETH Zürich
- European Graduate Program on Combinatorics, Geometry and Computation
- MERL

